Health Behavior Change Support Systems as a research discipline; A viewpoint

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ABSTRACT

As research on Health Behavior Change Support Systems (HBCSS) proliferates, meaningful management of the different findings is becoming a challenge. We argue that for the field to evolve, it is important to establish the study of HBCSSs as an independent research area, which means that instead of only applying theories from related disciplines to HBCSSs, we need to significantly extend and adapt these theories, or develop new theories, to explain the phenomena that are encountered.

Current research in HBCSSs is carried out in different disciplines, with a different approach in each of these disciplines. However, both the CeHRes roadmap and the Persuasive System Design Model show that HBCSSs are complex and the development and evaluation of these systems need to deal with this complexity to be successful. Therefore, an integrative approach is needed to study the combination of content, system, and context. Although research into the separate areas has yielded important findings that are discussed in this paper, we argue that an integrated approach of HBCSSs is useful. We discuss two examples to show how a truly integrative approach can be utilized to enhance the field involving tailoring, personalization, and support. In conclusion we present three practical and relatively easy–to-implement recommendations for researchers who want to contribute to this discipline: Avoid the black box, be specific about the terms used, and look past the borders of one's own discipline.

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1. Introduction

Behavior Change Support Systems (BCSS) are "socio-technical information systems with psychological and behavioral outcomes designed to form, alter or reinforce attitudes, behaviors or an act of complying without using coercion or deception." [1] Researchers who study Health Behavior Change Support Systems usually identify the target of their study just by adding the "health" prefix to all-inclusive definitions. As research on Health Behavior Change Support Systems (HBCSS) proliferates, meaningful management of the different findings is becoming a challenge. And yet, it is not evident how to compare and combine findings about HBCSSs, because one can't be sure whether two studies report findings about similar systems or not.

The study of HBCSSs currently is more of a collection of research carried out in different research disciplines than an independent research area. We argue that for the field to evolve, it is important to establish the study of HBCSSs as an independent research area, which means that instead of only applying theories from related disciplines to HBCSSs we need to significantly extend and adapt these theories, or develop new theories, to explain the phenomena that are encountered (for a similar argument in the information systems field, see Ref. [2]).

As a first step in this direction, in this paper we will discuss the issue of current research in HBCSSs carried out in different disciplines; introduce a theoretical background for a more integrated approach; highlight key findings of previous research; and discuss examples of where an integrated approach of HBCSSs as an independent research area may be particularly useful. In the discussion we will reflect on this first step and point towards the necessary next steps.

2. HBCSS research as a collection of studies from different disciplines

There has already been ample research on the effectiveness of Health Behavior Change Support Systems, and there have been

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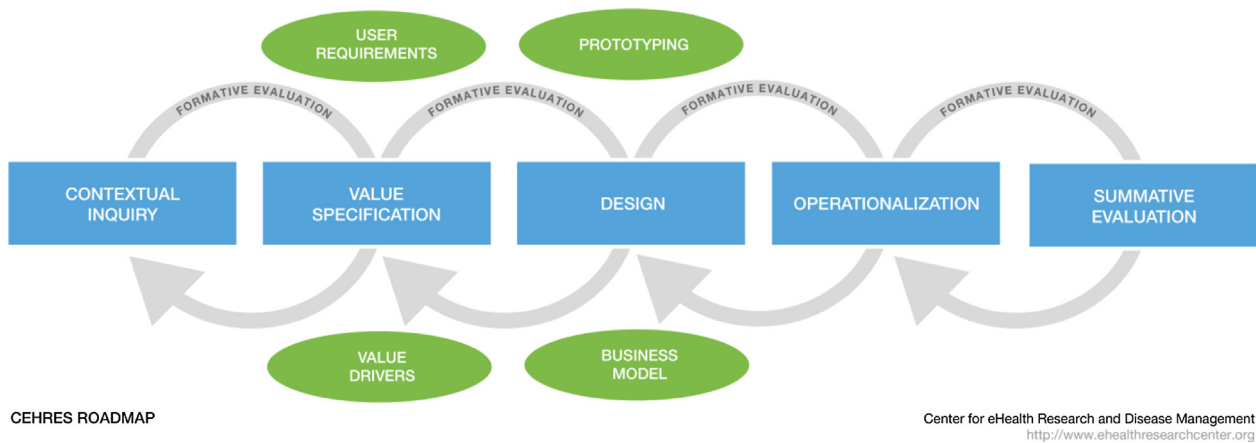E-mail address: s.m.kelders@utwente.nl (S.M. Kelders).

Fig. 1. CeHRes Roadmap for eHealth development [23].

numerous reviews that investigate the effectiveness for different target groups and health areas (e.g. psychotherapeutic interventions [3], depression [4], smoking [5], positive psychology [6], health behavior change in general [7]). Most of these studies conclude that HBCSSs can be effective, but do not always achieve the desired effects. Although drawing this conclusion may not be unique to only this research area and question at hand, the interesting part is how the researchers aim to discover why some systems perform quite well and others really don't. Some researchers investigate whether the content of interventions can be used to discriminate successful from unsuccessful HBCSSs (e.g. [3,7]). Others focus more on the set-up (e.g. [5,6]) or on contextual factors like the inclusion of human support (e.g. [4]). A different group of systematic literature reviews investigates the technology used in HBCSSs (e.g. [8,9]). All these different foci seem to yield some insight into successful factors, but there appears to be no overarching idea how to tie all these insights together in order to learn how to build a successful HBCSS.

This focus on different, separate aspects is not only seen in literature reviews, but also within single intervention studies. There are those that, for instance, test the experiences and effectiveness of interventions that vary on content (e.g. [10]), there are those that test different technological features (e.g. [11]), and there are those that test more contextual factors like the amount and method of giving support (e.g. [12]).

Furthermore, not only do different studies investigate different aspects, these different studies are also published in different outlets. A main difference seems to be where the studies with a more 'technical' focus are published (e.g. on conferences like CHI [Computer Human Interaction], ICIS [International Conference on Information Systems] and in journals like AIS Transactions on Human-Computer Interaction) v. where the more content-oriented studies are published (e.g. in psychological journals like Cognitive Behavior Therapy, or health related journals like BMC Public Health). There are only a few outlets that seem to publish both type of foci (e.g. Journal of Medical Internet Research, and International Journal of Medical Informatics). These options are limited, which inhibits the progress of the field.

These disparate approaches seem to foster the Black Box issue [1,13]: There is insight regarding whether online interventions work, but only limited insight is gained on why and how they work. This disconnect severely hampers the development of successful HBCSSs (see e.g. [14–16] for further discussion). For example, a study focused on specific content-related questions (e.g. what theoretical basis is optimal for a particular target group) will probably focus only limited attention on the technical features of the intervention. This means that the technical side remains a black box. On the other hand, a study focused on the added value of system features often provides only a little information on the content used and the theoretical background behind this content. In this case, the content remains a black box. This problem has been acknowledged, for example, in different systematic reviews; when comparing and bundling studies on different interventions it becomes even more apparent that studies differ greatly on what they report on the studied interventions [8,17].

That researchers focus on topics that align with their background has led to a great number of insights that have helped the field evolve. However, we feel that we are now at a stage where more is needed to move forward. We need to look beyond the borders of our own research areas and learn from each other to establish the study of HBCSSs as an independent research discipline.

3. Theoretical background

By no means do we claim to be unique in advocating a multi-disciplinary approach or to look beyond the borders of one's own discipline. Just for instance, see the CONSORT-EHealth statement, for example, to list the information that studies should mention about studied interventions [18], and thus help overcome the black box issue; Pagliari's interesting and relevant viewpoint detailed the need for and challenges of interdisciplinary work in the design and evaluation of eHealth [19]; or Hekler et al.'s paper about better usage of behavioral theories in HCI (Human Computer Interaction) related research [20]. Furthermore, there have been other works stressing the importance of the informational content provided, the information system used, or many of the contextual factors for effectiveness of Health Behavior Change Support Systems (e.g. [21,22]). However, we feel that with the growing pace of technology development, and the attendant opportunities for HBCSSs and research about them, an integrative approach is needed now more than ever.

The three intertwined components, which also reflect three different views on an HBCSS, are content, system, and context. The frameworks underlining our integrative viewpoint on these components, and for the design, development, evaluation, and research of eHealth technologies, are the CeHRes roadmap [23] and the Persuasive System Design Model [24]. Both will be introduced in the following paragraphs.

3.1. CeHRes roadmap

The Center for eHealth Research and Development (CeHRes) Roadmap provides a practical guideline to achieve eHealth inter-
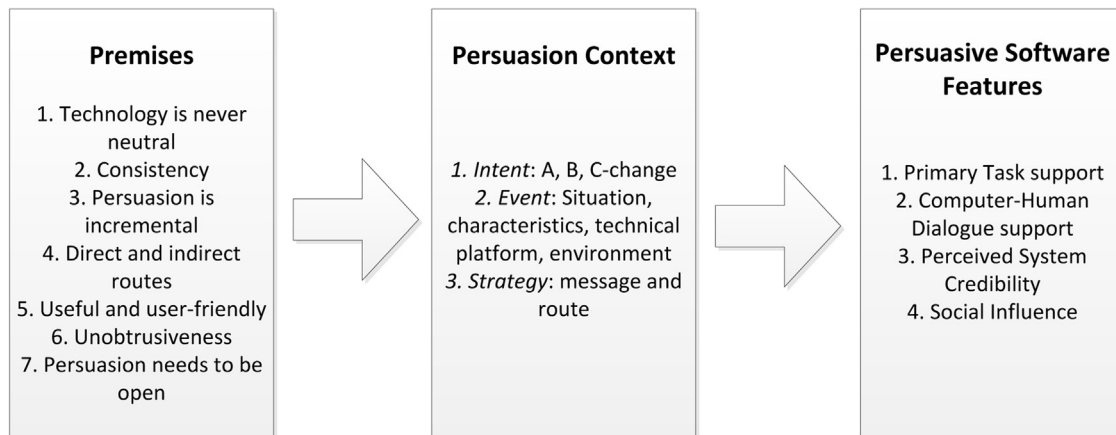
Fig. 2. Persuasive System Design model [24].

ventions that are user friendly and implementable in practice [23] (Fig. 1). The holistic approach is based on persuasive technology theories, human centered design approaches and business modeling. Persuasive technology refers to the capacity of technology to influence behavior and is used in eHealth research to understand the role of technology in changing behavior [24,25]. Human centered design advocates the systematic, continuous consultation of potential users during the whole design process [26] and has been shown to have a positive effect especially on user satisfaction and fitting the system to user needs [27]. Business modeling stems from commercial strategic management [28] and focusses on value creation with stakeholders. The business model approach can be used to make the development of eHealth technology values-driven, i.e. technology that matches the values of and makes sense to the different stakeholders [29].

The six working principles that underlie the CeHRes roadmap for eHealth development are as follows:

1. It is a participatory process;
2. It involves continuous evaluation cycles;
3. It is intertwined with implementation;
4. It changes the organization of health care;
5. It should involve persuasive design techniques; and
6. It needs advanced methods to assess impact.

The roadmap itself (Fig. 1) consists of six research and development activities. Before the actual start of the development process, a multidisciplinary project management should be established that facilitates iteration between the creators and the users of the system. In short, the steps are as follows: In the contextual inquiry information is gathered from the intended users and their environment to see whether there is a need for technology and how this technology might fit into the daily routines of the intended users. The value specification builds on the results of the contextual inquiry and here the key stakeholders determine and rank their values. These values are cooperatively translated into requirements of the technology. In the design step a prototypical version of the technology is developed, based on the requirements. The operationalization phase concerns the introduction, adoption, and deployment of the technology in practice, and involves for example training and education of health care workers. The last stage is summative evaluation, in which the actual uptake and impact of the technology regarding clinical organizational and behavioral effects, is assessed. As a whole, the roadmap provides a comprehensive development strategy and is intended to improve the uptake and impact of eHealth technologies.

3.2. The Persuasive System Design model

The Persuasive Systems Design (PSD) model advocates the systematic evaluation of the following:

1. the premises behind any persuasive system,
2. the Persuasion Context, and
3. the persuasive system features [24] (Fig. 2).

All HBCSSs are based on seven premises stemming from information systems design and psychology [24]:

1. Technology is never neutral—rather it always influences attitudes and behavior.
2. People like their views about the world to be organized and consistent [30].
3. Persuasion is often incremental: This means that persuasion goes stepwise, and all steps contribute to the goals to be realized.
4. Persuasion strategies can be divided into direct and indirect routes, and persuasion will depend on the ability and motivation of people to process information. The background, context and other factors may influence the routing of information [31].
5. Persuasive systems system should be both useful and user-friendly.
6. Persuasive systems should be unobtrusive, i.e., the system should avoid being disturbing while the user is performing tasks.
7. Persuasive designs should be open, i.e., designers should make the ideas behind and the goals of persuasion transparent.

The analysis of the persuasion context consists of looking into (1) the Intent, (2) the Event and (3) the Strategy [24]. A behavioral change that is the intended outcome of a HBCSS is divided into three categories [13]:

- C-Change is a change in compliance, for example, a trigger can lead to change in complying with a certain request, such as medication intake
- B-Change is an enduring change in behavior; and
- A-Change is a change in attitudes.

The outcomes of an HBCSS are the formation, alteration or reinforcement of the three types of change. The Event comprises the use situation, user's characteristics, and technological platform and environment. The Strategy includes the message itself and the route to be used to achieve the change.

The PSD model describes persuasive software features in the categories (1) Primary Task support, (2) Computer-Human Dialogue

support, (3) Perceived System Credibility and (4) Social influence [24]. Primary task support focuses on persuasive techniques that support carrying out the primary activities, that is the activities that lead to achievement of the goals of the HBCSS. Dialogue support refers to human-computer dialogue and techniques to motivate users to use the HBCSS and achieve the goals. The perceived system credibility design principles relate to the believability of design and trustworthiness of the system. The social influence principles describe how to design the system so that it motivates users by leveraging social support of others. The PSD model provides a method to systematically look at how persuasive software features and their categories are used in current technological interventions. Moreover, it provides ideas on how to design these interventions to be more persuasive.

3.3. Integrative approach

As seen from both frameworks, HBCSSs are complex. The development and evaluation of these systems need to deal with this complexity to be successful. Another common point is that an HBCSS is seen as more than only the content. Technology, the system itself, matters, and it influences the users even if it is not intended to do so [1]. This is not beyond our control. On the contrary, this influence is one for which the system can and should be designed. Simultaneously, the content matters: In the PSD model, this is apparent in the postulates dealing with incrementality and indirect routes to persuasion. In the CeHRes roadmap, the content is very much intertwined with the system: e.g. the technology is seen in a holistic way where there is no real separation between system and content; it is one and the same. Finally, the importance of context is evident in both frameworks. In the CeHRes Roadmap, the starting point is the contextual inquiry, and in the PSD model, analysis of the persuasion context is a crucial step for any development or evaluation.

4. Important insights from content, system and context

Before proceeding, it is important to attempt to specify the meanings of content, system, and context. By no means are they mutually exclusive. The emphasis is on studying them in combination in the integrative approach, yet it's important to define each one.

By *content*, we mean the way that the Health Behavior Change Support System attempts to change the behavior of the user. Often this is based on behavior change theories or therapeutic approaches, or implemented by behavior change techniques. Content is often implemented in the HBCSS as text or video.

By *system*, we mean the technological mode and features used to deliver the content. These system features can be looked at from, for example, a persuasive technology point of view (e.g. PSD model), or from a more descriptive viewpoint (e.g. videos, text messages, email).

By *context*, we mean the aspects that are related to how the HBCSS is implemented in the specific context. Examples are organizational factors, whether there is communication with a care provider or peers, and if so how, whether the HBCSS is to be used at home or another place, and how often the HBCSS is supposed to be used.

4.1. Important insights from content

Many studies in the content field have been carried out to investigate whether insights from the offline or face-to-face world also hold true for the online world. The answer seems to be yes: We have seen that online interventions can effectively make use of the same therapeutic approaches as offline interventions [3,4], and we have seen that basing interventions on theory is as important in an online environment as in the offline environment [7].

The content of many HBCSSs comes from protocols for offline health interventions. This content is often adapted to a greater or lesser extent to fit the medium and target group for that particular intervention. This may mean shortening the text of a self-help book to fit in a weekly intervention [32], or adapting outpatient evidence-based treatments for chronic pain [33]. At other times, the content is specifically made for the HBCSS. Often the content is then based on behavior change theories (see e.g. [34,35]), and is developed together with the intended target group or by asking their feedback (e.g. [36–38]). In most ways, the content is specifically designed for the HBCSS, and when it is adapted from offline content, behavior-change techniques are added to help users change their behavior. These behavior-change techniques stem from various behavior change theories [39], and the implementation of these techniques is related to an intervention being effective [7]. Research also has shown which behavior-change techniques are most effective in which types of interventions (e.g. [40,41]), however recommendations about which techniques to include in a specific HBCSS are still difficult to make.

More recently, especially due to the rise of mobile technology and increasingly interactive systems, the question arises whether traditional behavior-change theories are still adequate for the development of HBCSSs. These theories seem to be less suitable to inform the design of systems that emphasize interactivity and adaptivity [42–44]. Bandura already stated in 2001 that theories need to be critically appraised before putting them into use in a different context [45]. In our view, theories that address dynamic feedback and how interaction with technology can lead to behavior change are needed. This is an area where integration of research in the fields of information systems, human-computer interaction, and behavior change may lead to great improvements [20].

4.2. Important insights from systems

One of the main findings from the systems field seems to be that a number of (persuasive) technology features are able to increase adherence and effectiveness of HBCSSs [8,46,47]. In particular self-monitoring, tailoring, and reminders have been well studied with mostly positive results [48–51]. When looking at broader categories of features instead of separate features, it seems that dialogue support plays a pivotal role in increasing adherence and effectiveness [8,47,52].

A large systematic review on persuasive systems attempted to answer the question whether these systems are actually persuasive [53]. The results showed that more than half of the included studies demonstrated positive results and more than 90% demonstrated partially positive results. However, the studies showed methodological concerns, so these numbers should be interpreted with caution. Moreover, this review did not make an attempt to study the effectiveness of individual strategies, mainly because most of the primary studies did not explicitly report on them, which makes it hard to conduct such an analysis after the fact.

Apart from studying the effectiveness of system features, there have been a number of studies into the kind of system features that are used in HBCSSs. It appears that some features that support the primary task, e.g. self-monitoring and reduction, are used often in both mobile and web-based HBCSSs [8,9,54–56]. However, these studies also conclude that the studied HBCSSs do not take full advantage of what technology has to offer, so there is room for improvement.

Some recommendations on how to develop systems also have come from studies on specific persuasive technology strategies like suggestion [57], or from theories and theory-based studies [58,59]. This has led to a design space for suggestion tactics [57], and general

design guidelines like using abstraction, reflection, and social interaction [58,59]. Although these studies provide valuable insights, more in-depth work needs to be done on validating and studying the effectiveness of these recommendations.

4.3. Important insights from context

When looking at studies from the context field, there are a number of research areas that have received considerable attention. In this paragraph, we will discuss three of them: The provision of support, choosing the right persuasion strategy for an individual, and for whom are HBCSSs most beneficial.

Considering the provision of support within HBCSSs, although it is hard to draw a firm conclusion, it seems that some support given through a HBCSS is beneficial to both adherence and effectiveness, but what kind of support and by whom (including technology) is yet to be determined [12,60,61].

When choosing the right persuasive strategy for an individual, different user characteristics are considered. Personality, for example, seems to influence the perceived persuasiveness of a system, and therefore, may be a useful variable to keep in mind when designing HBCSSs [62,63]. Other variables that have been shown to influence the perceived effectiveness of different strategies are gender [64,65] and gamer type [66]. However, this makes it difficult to select the best variable on which to focus. To overcome this issue, researchers have taken a more practical approach to more directly assess a user's persuadability profile: They have tested the user's response to the different strategies and then picked the strategy by which the individual user is most persuaded [67,68].

The third area is for which users HBCSSs seem most beneficial. To be able to answer this question, we first need to know who the people are that normally use HBCSSs. In many cases these systems are used by educated females around 40 years old (see e.g. [47,69]). To determine which users most benefit from HBCSSs, post-hoc analysis of RCT-type studies are carried out, in which different characteristics of participants related to increased effectiveness are investigated. One of the aspects that has been shown to be related to effectiveness is adherence [70], i.e. the degree to which the HBCSS is used as intended. Much work has been carried out on which participant characteristics predict adherence. Numerous characteristics that influence adherence have been identified, including gender, age, and disease severity, however the predictive power of these characteristics remains low [69,71–73]. At this time, it seems impossible to draw a generalizable conclusion, other than the HBCSS needs to fit with the characteristics of participants to be most beneficial.

5. Integrated approach

Below we present two topics that have been studied by using the different approaches, in which it remains challenging to draw firm conclusions on how to best implement the topics in HBCSSs. We use these topics as examples of how a truly integrative approach can be utilized to enhance the field.

5.1. Example: tailoring and personalization

Tailoring and personalization have been studied both as a content topic and as a systems topic. In both fields, the added value has been shown in different contexts (e.g. [74–77]). However, as the terms are used differently in these fields, it remains relatively hard to compare and integrate the results into a useful guideline for developing HBCSSs. For instance, in health education, mentioning the name of the participant is already called personalization (see [78]). In this field, tailoring is seen more as adapting the content of

the intervention to a particular group of people (see e.g. [79]). However, in the field of information systems, personalization is seen as consisting of adaptation (automatic, implicit personalization) and adaptability (the system provides the opportunity to the user for customization) of the content, presentation, navigation, and user input [80]. This is a much broader definition of the concept of personalization although it does not seem to encompass tailoring as used in health education. Others distinguish targeting and tailoring, where targeted messages are customized to a specific subgroup and tailored messages are based on specific individual characteristics [81]. This seems to be opposed to the earlier definition. What these differences in definitions show is that it is very hard for a researcher in one field to learn from research in a different field, and that the fields seem to live a life on their own. A truly integrative approach here could start with a thorough understanding of all related fields bringing the results from different fields together in one nomenclature. That could be a starting point for addressing questions like how to best personalize HBCSSs. For instance, is it enough to personalize just the content or the system separately? What ways are there to personalize? When should personalization and when should tailoring be used?

5.2. Example: support

As stated before, support for change is a topic that has received considerable attention within different academic disciplines. It seems clear that including some form of support in any HBCSS is needed for adherence and effectiveness, but much remains unclear about what this support needs to be and how it needs to be provided. Questions that remain, for example, in the field of HBCSSs for mental health, where support is mostly given by human counselors, are whether the actual involvement of a counselor leads to the positive effects of support or whether this stems partly from other factors like having clear deadlines within the treatment [4] or contact before and after treatment [82]. Furthermore, questions remain on the needed source of the support: it is not essential to have a therapist provide non-clinical support to produce significant benefits; support may be provided by a layperson which has no clinical role [12,61]. This poses questions on whether this support can be automated [4,82]. Earlier studies have shown that automated support can be effective although less so than human support or with lower adherence rates [83–85]. However, the automated support examined seems to have been very basic, e.g. standard messages send via email at standard times.

Within the Human-Computer Interaction and Information Systems disciplines, much more work has been carried out on employing automated support within HBCSSs. Here, often, the question is not whether automated support is as good as, or better than, human support, but about different ways to make automated support more effective. For example, the number or mode of reminders is investigated [86], the added value of context aware feedback [87], or how to best present feedback to the user [88]. However, these automated support messages are often written by the researchers in these fields and not by health care professionals or based on behavior change theories [86–88].

It seems that there is much to learn about the possibilities of automated support for the more clinical researchers in eMental health, but researchers in HCI and IS fields, for example, may also be able to learn what makes human support effective for incorporating these lessons as automated support. Using this type of an integrated approach has led to promising results. For instance, automated support in a HBCSS for depression, employing tailored feedback messages (i.e. feedback was based on the answers to multiple choice questions the users filled out) and social presence,

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Summary points

What was already known on the topic

- Research on Health Behavior Change Support Systems (HBCSS) proliferates.
- HBCSSs are complex and the development and evaluation of these systems need to deal with this complexity to be successful.
- Current research in HBCSSs is carried out in different disciplines, with a different approach in each of these disciplines.

What this study added to our knowledge

- An integrative approach is needed to study the combination of content, system and context.
- The paper provides on overview of research to date on content, system and context of HBCSS.
- We give two examples to show how a truly integrative approach can be utilized to enhance the field: tailoring and personalization; and suppor.
- We present three practical and (relatively) easy to implement recommendations for researchers who want to contribute to this discipline: avoid the black box; be specific about the terms used; and look past the borders of one's own discipline.

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showed that automated support was as effective at follow-up as human support, with the same rates of adherence [60].

6. Discussion and implications

This paper attempts to take the first step to treat research on Health Behavior Change Support Systems as an independent discipline. Our aim was to show that at the moment, research into HBCSSs seems to be more a collection of studies from different disciplines about the same concept, i.e. HBCSS. Although this has led to important insights, it makes it difficult to combine different insights due to lack of information about and standardization of terms. Moving forward as a discipline is important to open the black-box of HBCSSs in term of content, systems, and context to be able to better understand and develop HBCSSs and to make a contribution to higher quality health care with a broader reach.

Practical and relatively easy to implement recommendations for researchers who want to contribute to this discipline are first and foremost to *avoid the black box*: Clearly report the content, system, and context of the HBCSS investigated, and think about using methodologies that can open this black box [15]. A second recommendation is to *be specific about the terms used*: When using a term that is used differently in different fields, do not assume the reader knows which definition you use, but state the definition. A third recommendation is to *look past the boarders of one's own discipline*: Try to find related papers in a different field or try to go to a conference outside your own discipline. This is likely to provide new insights for a next paper or project.

Besides these practical recommendations, steps need to be taken to truly establish an independent research discipline for HBCSSs. Following the compelling argument made in the related field of Information Systems, there are two important steps: we need to find a specific research focus that is not the focus of other disciplines, or we need to approach this focus from a new perspective, and we need to build theories that explain or account for the phenomena we encounter. These theories can be based upon existing theories from other disciplines, of course, but they need to be truly different for research into HBCSS to become an independent discipline [2]. In this paper, we have explored the first of these steps by identifying a need for an integrative approach to the content, sys-

tems, and context of HBCSSs. However, much more work remains to be done both on identifying a specific focus and building theories to address this important research discipline.

Author contributions

Saskia Kelders: conceived the idea for the paper, conducted literature analysis, drafted the first version of this paper, Harri Oinas-Kukkonen: discussed the idea and structure of the paper, conducted literature analysis, edited the paper. Anssi Oörni: discussed the idea and structure of the paper, edited the paper. Julia E.W.C. van Gemert-Pijnen: discussed the idea and structure of the paper, edited the paper. All authors give their final approval of the submitted manuscript.

Conflict of interest

None.

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